LIBRARY CAPACITY SCALING BY INCREMENTAL ADDITION OF HORIZONTAL STORAGE TRAYS

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates generally to media storage libraries and more specifically to methods of scaling library size.

2. Background of the Invention:

Typical library structures are limited in capacity growth due to vertical wall geometry. In this type of geometry, storage cells are arranged in vertical arrays along the wall of the library, wherein picker robots move along the wall to retrieve items from the storage cells. To extend the size of such a library, a wall or group of walls must be added. If a library storage wall is defined by a plane in X (horizontal) and Y (vertical) coordinates, with a Z coordinate coming perpendicular out from the wall into the robot space, then to grow the library, the only option for gaining storage cells is in the X direction. This is because Y expansion is limited by the room ceiling height, and the Z direction is where the robot operates.

Therefore, it would be desirable to have a method that allowed for scaling libraries in all three dimensions.

SUMMARY OF THE INVENTION

The present invention provides a method for scaling a storage library, the library comprising at least one horizontal array of storage cells arranged in rows and columns, and at least one robot that moves on guide rails along the length of the horizontal array and can retrieve objects from and place objects into the storage cells. The present invention comprises expanding the library longitudinally along the guide rails and/or expanding the width of the library. Longitudinal expansion is accomplished by adding more horizontal storage cell arrays end-to-end. Width expansion is accomplished by means of side-by-side accumulation of additional horizontal storage cell arrays.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, further objectives and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

Figure 1 depicts an isometric pictorial diagram illustrating a library unit with horizontal storage arrays in accordance with the present invention;

Figure 2 depicts a front isometric view pictorial diagram illustrating the composite library system in accordance with the present invention;

Figure 3 depicts a rear isometric view pictorial diagram illustrating a composite library system in accordance with the present invention;

Figure 4 depicts a top view pictorial diagram illustrating the composite library system in accordance with the present invention;

Figure 5 depicts a cross-section, side view pictorial diagram illustrating a horizontal library unit in accordance with the present invention;

Figure 6 depicts a pictorial diagram illustrating guide track switching mechanisms for each horizontal level in accordance with the present invention;

Figure 7 depicts a pictorial diagram illustrating a Y joint in a track switch in accordance with the present invention; and

Figure 8 depicts an isometric view pictorial diagram illustrating an outer route guide rail mechanism in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to **Figure 1**, an isometric pictorial diagram illustrating a library unit with horizontal storage arrays is depicted in accordance with the present invention. It should be pointed out that **Figure 1**, as well as all of the figures discussed below, depicts the library system without side covers, so that the internal components may be viewed.

Library unit **100** represents the basic design from which larger horizontal library systems can be built. Media elements (i.e. cartridges) are stored in horizontal array trays, e.g., **101**, which are arranged in multiple rows. The horizontal arrays are comprised of storage cells arranged horizontally in rows and columns. Media cartridges within the storage cells are retrieved and replaced vertically.

Robotic accessors, e.g., **102**, utilized horizontal guide rails, e.g., **103**, to move along the array trays **101** in order to access the media elements. The robots **102** use propulsion motors and drive wheels to move along the guide rails **103**. The guide rails **103** may also be used to allow the horizontal array trays **101** to slide in and out of the enclosure of library unit **100**. Alternatively, separate guide rails may be provided to facilitate removal of the storage cell trays **101**.

Library unit **100** contains media reader units **104**, power supply units **105**, and a controller **106**. **Figure 1** depicts an open cartridge access port (CAP) **107** and pass-

through tray **108**, which are included for each horizontal row in library system **100** and allow media cartridges to be passed between adjacent library units, as explained in detail below.

The typical prior art library is configured with vertical cartridge storage walls made up of storage cells arrayed in a vertical plane or curved wall. The storage cells in such a library may be removable to allow access into an enclosure. However, the media storage slots making up a storage wall are seldom deep enough to gain an advantage when removed; i.e. the removal of a wall does not create enough additional space for a human operator to fit through the narrow pathway.

The present invention of the horizontal array structure permits the storage density of a library to reach a new maximum limit, based on robot size, not human size. The horizontal array trays can be packed as closely together as robot height permits, without the need to leave room for a human operator to access components within the enclosure. An access isle can easily be created by removing some of the horizontal arrays, e.g., **101**, to gain access (illustrated below).

Referring to **Figure 2**, a front isometric view pictorial diagram illustrating the composite library system is depicted in accordance with the present invention. This composite library is comprised of library unit **100**, depicted in **Figure 1**, as well as two larger interconnected units **200** and **210**. Library units **200** and **210** share the same basic horizontal layout as unit **100** but are larger.

The view depicted in **Figure 2** illustrates how human operators may access the storage elements and media readers within each of the library enclosures **100**, **200**, and **210** from the front side. The array tray support structure are designed with linear guide rails, e.g., guide rail **103** in **Figure 1**, that allow an array tray to be removed from the library by simply sliding the tray outward (down the end of a guide rails) until the end of the rail is reached, thus allowing the tray to be completely removed from the library structure. Array tray **201** illustrates a tray that is partially withdrawn from library enclosure **200**. Access space **202** illustrates how a service isle may be created when multiple array trays are completely removed from the library enclosure, as explained above. The horizontal configuration allows the design to take advantage of the storage array size to set the width of the pathway created when array packages are removed. For example, by creating a storage array tray of 16 cartridge slots, an isle width of 20 inches can be obtained between support structures for the array trays.

In addition to removing single trays, the array tray modules could be hooked together to form a group of trays, such that by pulling an endmost tray, all of the other trays connected to it would slide out to gain full access to all the trays. This process can be performed by an operator or possibly with automated electro-mechanical motors for large systems with many trays, e.g., enclosure **210**.

Figure 2 also depicts the housings for the pass-through mechanisms **220** and **230** that connect the three library enclosures **100**, **200** and **210**. The operation of these pass-through mechanisms **220** and **230** are discussed in more detail below.

Referring to **Figure 3**, a rear isometric view pictorial diagram illustrating a composite library system is depicted in accordance with the present invention. As can be seen from this angle, library unit **210** does not contain its own media readers. Cross-enclosure pass-through mechanisms **220** and **230** are able to transfer media cartridges from enclosure **210** to the appropriate media readers in enclosures **100** and **200**.

With prior art vertical wall libraries, adding storage walls requires the robot accessors to have a path intersecting at a common "lobby" in front of the media readers, wherein paths intersect in orthogonal directions to reach the common area. These vertical designs require extra guide rails that may have to intersect to get the robots into the shared space in front of a tape reader unit.

For horizontal storage, capacity is added without having to join robot spaces in a common "lobby" near the tape reader units. The horizontal configuration of the present invention uses "cross tracks" within the pass-through mechanisms **220** and **230** to move cartridges between expansion units to get the tapes in front of the appropriate media reader.

Referring to **Figure 4**, a top view pictorial diagram illustrating the composite library system is depicted in

accordance with the present invention. **Figure 4** more clearly illustrates the components of the pass-through mechanisms **220** and **230** and cross-track features.

The pass-through mechanisms **220** and **230** rely on a cross-cabinet (or across-the-cabinet) guide rail **401**, which can move media cartridges (or robots themselves) against the grain of the normal robot flow. The cross-cabinet guide rail **401** runs through each horizontal row within the library enclosures **100**, **200**, and **210**. The cross-cabinet guide rail **401** serves as a movement path 1) to get media in between adjacent banks of storage cells, 2) to provide an easy access method for cartridge entry into the library, and 3) to provide a method for movement of cartridges (or robots) between library enclosures.

For example, cross-cabinet guide rail **401** allows media cartridges to move between adjacent storage cell banks **402** and **403**.

Cartridge access port (CAP) **404** allows easy access for adding or removing media cartridges from enclosure **100**. Additional CAPs **405**, **406** and **407** are provided on each side of enclosures **100** and **200** to allow motorized pass-through trays, e.g., **408**, to carry cartridges between enclosures **100**, **200**, and **210**. Though not pictured in **Figure 4**, it should be pointed out that CAPs are placed on all horizontal levels within enclosures **100** and **200**.

Another embodiment comprises the movement of the actual robotic accessors between sections of the enclosure, using track joints and sub-rails. This approach is very similar to the pass-through tray method

described above, except that robots are used to carry media cartridges between enclosure and reader, rather than pass-through trays.

The use of horizontal array structures permits the library to grow easily in three dimensions. As explained above, the library may be scaled vertically by adding more horizontal trays and packing them closer together, subject to the limitations of robot size. However, vertical scaling is still limited by the ceiling height.

In addition to vertical scaling, the horizontal library also allows horizontal scaling in two directions. Horizontal library expansion can occur in both the z direction (longitudinally along the robot guide track) and the x direction (increased width).

The different library enclosures **100**, **200** and **210** in **Figure 4** clearly illustrate horizontal scaling in both the x and z directions. Scaling the width of a horizontal library can be accomplished by adding additiona [illegible] of horizontal arrays, or by increasing the width of each array. In **Figure 4**, width scaling is accomplished via increased number of array banks. Enclosure **100** is comprised of two side-by-side horizontal banks **402** and **403**. Enclosure **210** has three side-by-side banks **413-414**, and enclosure **200** has four side-by-side array banks **409-412**.

Longitudinal scaling may also be accomplished by either increasing the number of array trays, or by increasing the length of each array tray. **Figure 4** illustrates longitudinal scaling by means of additional horizontal trays arranged end-to-end along the guide

rails. For example, horizontal array bank **402** in enclosure **100** in comprised of two end-to-end array trays **416** and **417**. Array bank **412** in enclosure **200** is twice as long, containing four end-to-end trays **418-421**. Bank **413** in enclosure **210** comprises six end-to-end trays **422-427**.

Because the robots in the horizontal library move horizontally over the storage cells arrays, expansion in the z direction does not crowd into robot operational space, as is the case with vertical wall libraries.

Referring to **Figure 5**, a cross-section, side view pictorial diagram illustrating a horizontal library unit is depicted in accordance with the present invention. **Figure 5** illustrates how Robots, e.g., **502**, are translated between different horizontal levels within the library. Guide track switches **501** at each level allow the robots **502** to switch between horizontal guide rails, e.g., **504**, and a vertical guide rail **505**. This enables robots **502** to move between different horizontal levels, as well as move between different media readers/drive **503**, which are stacked vertically along vertical guide rail **505**.

Referring to **Figure 6**, a pictorial diagram illustrating guide track switching mechanisms for each horizontal level is depicted in accordance with the present invention. The embodiment of the track switch depicted in **Figure 6** uses a "Y" junction **605** wherein a motor or other actuator controls the position of a moving guide rail **606** around a pivot point **607**. This allows the moving guide rail **606** to be aligned with a fixed curve track **603**, thus allowing robot **601** to make the

transition from the vertical rail **604** to the horizontal rail **602**. The Y joint is an application of the "turntable joint" (round house) used in railroad examples. The mechanical working of the Y joint are described in more detail below.

Referring to **Figure 7**, a pictorial diagram illustrating a Y joint in a track switch is depicted in accordance with the present invention. A partial robot structure **700** and robot propulsion motor **701** are illustrated attached to the guide rails. The Y joint **710** is moved by actuator gear **720** (motor not shown). The Y joint **710** has two partial rail sections: a straight section **713** and a curved section **711/712**. The curved section of rail is shown in two different positions: disengaged **711**, and engaged **712**.

When the Y joint **710** is brought forward by the actuator gear **720**, the curved rail section **711** is disengaged, and the straight section **713** is engaged with the vertical track **730**. In this forward position, the robot **700** will continue to move along the vertical track **730**.

When the Y joint **710** is brought backward by the actuator gear **720**, the straight section **713** is disengaged, and the curved section **712** is engaged with the fixed curved rail **740**. In this position, the robot **700** can move onto the horizontal guide rail **750**.

Another embodiment of the track switch uses a "passive" Y joint, wherein a spring-loaded moving track section would let a robot pass through it to get on a fixed rail. If the robot comes back the other way, the

moving section would be fixable to cause the robot to go onto only one of the rail sections of the Y track. This design effectively creates one-way traffic for the robots, because the robots can always be guided forward through the track switch, without returning over the same Y joint in the opposite direction.

Referring to **Figure 8**, an isometric view pictorial diagram illustrating an outer route guide rail mechanism is depicted in accordance with the present invention. The horizontal library design allows for the addition of guide rail structures **801** that provide a path of travel for any of the robots **804** to move in a loop back to the far end of the structure **800**. This provides a return path for continuous loading of data cartridges toward the tape reader units. The one-way robot traffic created by this approach limits robot contention and provides a constant stream of cartridge load jobs. Guide rail switches, e.g., **803**, are implemented at both ends of the horizontal storage cell arrays, e.g., **805**, to allow robots **804** to traverse up or down between horizontal rows.

A looping feed path is created by outer route layout, wherein a robot may be used in conjunction with another robot such that there is no contention between the robots. If the control software for the system is structured to force the movements of all robots to be in the same direction, and the robots can always loop forward to get to any desired position, then a state of operation can be achieved where no contention occurs between robots on the same track. The performance of the

system is improved because a robot is made available to dismount a drive concurrent with the requested mount of the same drive.

The description of the present invention has been presented for purposes of illustration and description, and is not intended to be exhaustive or limited to the invention in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. The embodiment was chosen and described in order to best explain the principles of the invention, the practical application, and to enable others of ordinary skill in the art to understand the invention for various embodiments with various modifications as are suited to the particular use contemplated.